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PETROGRAPHIC ANALYSIS OF A SELECTED AMPHIBIOLITE FROM CREIGHTON MINE, ONTARIO AND A DIABASE FROM LAC SAINT-JEAN AREA, QUEBEC

A.S. Wong
Rock Mechanics Laboratory

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INTRODUCTION

One amphibolite rock-core sample from Creighton Mine (2300 Level), Ontario and four diabase slabs from Lac Saint-Jean area, Quebec were selected for petrographic analysis. The amphibolite was cored during the early stage of preparation on the in situ heater experiment in 1976. The diabase slabs were originally purchased from the Beebe Granite Work, Beebe, Quebec and there is no information on the exact geological location of the rock. However, it is believed they come from one of the rock quarries in the vicinity of Lac Saint-Jean area in Quebec (K.N.M. Sharma, Quebec Department of Energy and Resources, personal communication).

These rock samples were cored for physical and mechanical properties investigations such as porosity, permeability, uniaxial, triaxial, shear and stiffness tests etc.

Three standard size (26 x 45 mm) rock thin sections were cut from the amphibolite and sixteen (4 on each slab) sections from the diabase slabs and were prepared by the Vancouver Petrographics Ltd., Vancouver, B.C. For quick plagioclase and K-feldspar identification, 6 selected thin sections were chemically stained by the cobaltinitrite technique.

PETROGRAPHY OF SPECIMENS

AMPHIBOLITE

The rock is a uniform, massive, dark-grey, fine to very fine grained amphibolite which displays an 'interlocking' texture (Fig. 1), and has been metamorphosed under amphibolite facies conditions. The major mineral constituents are hornblende, plagioclase, biotite and trace amounts of other minerals such as quartz, sphene, magnetite, pyrite, apatite scapolite and carbonate etc. (Table 1).

The hornblende is pleochroic varying from green to brown. The usual prismatic crystal forms are absent from the thin section that cut normal to core-axis. However, faint cleavages that are parallel along the c-axis of the hornblende are present. Thus the crystals shape tend to be elongated along the c-axis. The prismatic crystal shape of hornblende are present only from the thin sections that cut parallel to the axis of the core. The average grain size of the hornblende ranges from 0.3 mm on the elongated direction to

0.06 mm on the other (the elongation ratio is 5:1). Most of the hornblende are subhedral and always form an 'interlocking' texture that is either associated with hornblende itself or with biotite/plagioclase.

The white plagioclase is always fresh, rarely indicating any alteration, and albite and albite/carlsbad twins are always present. Magnetite, pyrite and apatite are commonly noted as inclusions. The average grain size is very fine and ranges from 0.5 to 0.6 mm. The grains are subhedral and approach toward labradorite in composition (An_{45} - An_{60}).

The biotite is peochroic from light brown to dark brown and pleochroic 'halos' are often present. It occurs mostly as subhedral to anhedral and the average grain size ranges from 0.3 mm on the elongated direction and 0.07 mm on the other direction (the elongation ratio is 4:1). The biotite crystals are always interlocking with hornblende or hornblende/plagioclase.

The colourless quartz occurs only in minor amounts and the grain sizes are generally very fine. The quartz grains are unstrained and commonly occur as inclusions or interstial to plagioclase, biotite and/or plagioclase. The apatite is always colourless with high relief and occurs in acicular forms (in some cases could be as long as 1 mm in length). The sphene is slightly pleochroic from pale brown to brown, very high relief and generally occurs in subhedral to anhedral aggregates. The opaque minerals are mainly magnetite and pyrite and mainly occur as inclusions in hornblende and plagioclase but rarely in biotite. The anhedral carbonate (calcite) occurs only along the filled fractures and occasionally, euhedral calcite crystals are also observed. Only a trace amount of scapolite is present.

The average mineral composition of the three thin sections (based on 1000 point count per section) are given in Table 1.

Two major filled fractures; one filled with quartz and the other with quartz and carbonate are present. The average apartures for the two fractures are 0.9 mm and 0.09 mm respectively (Fig. 2). Minor intergranular filled/opened fractures are also present. However, the intergranular fractures are almost absent. From Fig. 2, between the two sets of fractures, it is clearly evident that the quartz filled fracture developed prior to the quartz/carbonate fracture. In addition, a well defined lineation which did not intersect the two major fracture sets are also observed and suggest that the lineation was developed during the last stage of regional metamorphism.

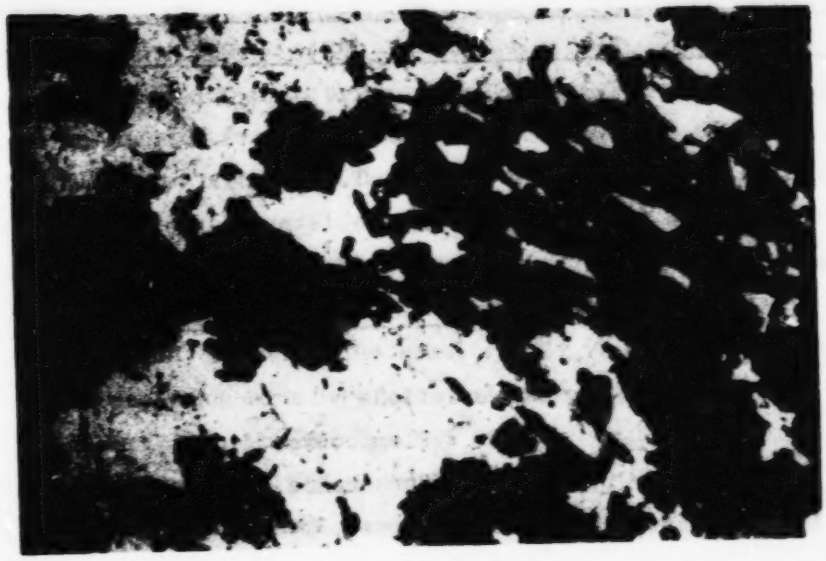

Fig. 1 - Photomicorgraph of the 'interlocking' texture of amphibolite. Crossed nicols. Horizontal dimension = 3.34 mm

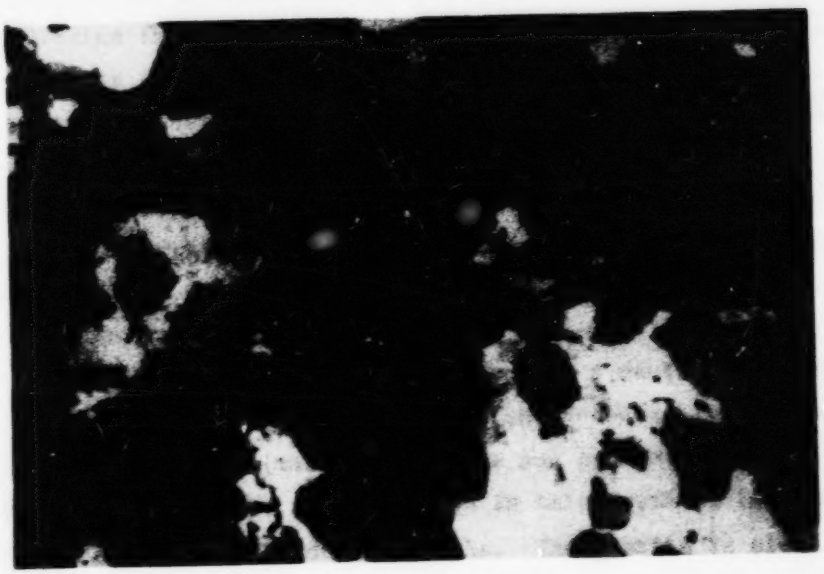

Fig. 2 - Photomicrograph of two fractures intersecting each other in the amphibolite. Crossed nicols. Horizontal dimensions = 3.34 mm

Table 1 - Modal volume percentage of mineral in amphibolite from Creighton Mine (2300 level), Ontario

RS	PLG	HRB	BIO	QTZ	SPH	OPQ	OTH	CONT
A	24.8	47.1	23.3	3.3	1.4	0.1	AP,SC	1000
B	24.3	48.5	20.2	4.0	2.6	0.4	CA,AP	1000
C	22.2	46.3	26.0	3.0	1.8	0.7	AP,SC,CA	1000
x	23.8	47.3	23.2	3.4	1.9	0.4	AP,SC,CA	
s	1.38	1.11	2.90	0.51	0.61	-		

Abbreviations

PLG = Plagioclase
HRB = Hornblende
BIO = Biotite
QTZ = Quartz
SPH = Sphene
OPQ = Opaque minerals
OTH = Others
CONT = Total point count
RS = Rock sample
AP = Apatite
SC = Scapolite
CA = Carbonate
x = average
s = standard deviation

DIABASE

The rock slabs are dark to greyish dark, fine to very fine grained, fresh, massive and unmetamorphosed aphanitic diabase. There are four similar diabase slabs involved in these studies and its exact geological location is not known but it is believed that it comes from Lac Saint-Jean area, Quebec and were cut from the same block of rock mass. Four separate thin sections are cut from each slab (for example: Ab, At, As and Av on which A=sample identification; b=bottom; t=top; s=side and v=vertical) and one section from each slab was selected for chemical stains on plagioclase and K-feldspar. The bulk magnetic susceptibility measurement was made at the Geomagnetic Laboratory, Earth Physics Branch, Ottawa. The results will be discussed later.

All 16 thin sections were carefully examined under an optical microscope. The major mineral consituents are 56% or more plagioclase, and 44% or less of augite, actinolite, biotite, prehnite, quartz, opaque minerals (magnetite, pyrite and ilmenite) and trace amounts of K-feldspar and sphene (Table 2).

The plagioclase occurs in two general forms, a rather stout or tabular form and usually the more cloudy with decomposition products (usually light brown colour), and a small long lath-shaped (0.5 to 0.6 mm in length) which appears quite fresh and with narrow albite twining or frequently combined with carlsbad twins (Fig. 3). The plagioclase is almost always labradorite with a slight tendency toward andesine composition (An_{30} - An_{55}).

The augite is generally not fresh and most of it has been altered to actinolite at its periphery and occasionally the later mineral entirely replaces the former with an encircling wreath of secondary opaque minerals (magnetite, pyrite and ilmenite) (Fig. 4). It is usually pale brown in colour and occasionally more intense purplish brown colour indicates the presence of titanium where trace amounts of sphene crystals are present.

The amphibole (in actinolite composition) is a deuteric alteration product after augite and is generally pale to light greenish colour and always associated with mafic minerals (mainly magnetite and pyrite).

The biotite is brown to reddish brown in thin section, tabular shapes are present and occasionally subhedral crystals. The biotite is also a deuteric product after augite and/or actinolite.

Magnetite, pyrite and ilmenite occurs in irregularly bounded mass or disseminated, often quite thickly through the augite or actinolite as inclu-

sions of dusty finely granular in aspect. The magnetite shows a tendency to peripherial arrangement around the altered augite indicative of its secondary origin and it is often surrounded by rims of secondary brown biotite (Fig. 4).

Phrenite is colourless and often occurs as aggregated and often sheaf-like and approach spherulites which may be called as 'bow-tie' texture is characteristic (Fig. 5).

High relief, colourless and shows six-side prismatic of tabular crystals of apatite are present as separate mineral grains or as inclusions to plagioclase. Only anhedral quartz are present. A few euhedral sphene crystals are also observed.

MAGNETIC PROPERTIES OF THE DIABASE

The magnetic bulk susceptibility of the diabase core sample was determined by the Geomagnetic Laboratory at Earth Physics Branch, EMR. The objective of the measurements was to provide information on the magnitude of geo-magnetization of the studied diabase. A relatively high susceptibility (30,000 Bison units) was determined for a core specimen of 44.7 mm diameter by 150 mm long.

Magnetic anisotropy measurements were also carried out on a smaller core (24 mm in diameter by 34 mm in length) sample that was drilled from the above-mentioned core. The objective of these studies was to determine the magnetic rock fabric and the homogeneity of magnetism of the diabase. A rather weak preferred direction (or magnetic plane) of geological orientation of the studied diabase was available, therefore, the geo-magnetic orientation and the geological orientation of the diabase cannot be correlated.

Table 2 - Modal volume percentage of minerals in diabase from Lac Saint-Jean area, Quebec

RS	PLG	AUG	ACT	BIO	APT	QTZ	PRH	KF	OPQ	SPH	CONT
Ab	57.8	8.6	5.6	8.5	3.1	2.9	4.2	0.2	9.1	-	1000
At	54.7	10.2	3.7	9.9	2.3	2.8	5.9	0.2	10.3	-	1000
As	52.6	10.8	5.4	9.7	2.7	1.7	5.2	0.2	11.6	0.1	1000
Av	52.8	11.4	5.0	8.3	3.1	2.2	4.5	0.8	12.0	-	2400
Xa	54.5	10.3	4.9	9.1	2.8	2.4	5.0	0.4	10.8	TR	
Bb	56.1	12.7	4.6	8.3	3.3	1.1	4.3	TR	9.6	-	1000
Bt	54.5	11.3	3.1	10.3	3.9	1.9	2.8	TR	12.2	-	1000
Bs	57.2	12.5	3.2	8.8	2.7	1.7	3.4	0.2	10.3	-	1000
Bv	56.2	9.8	4.3	7.7	2.8	1.3	5.3	TR	12.6	-	2400
Xb	56.0	11.6	3.8	8.8	3.2	1.5	4.0	TR	11.2	-	
Cb	55.2	10.6	7.3	7.0	3.4	1.0	5.0	TR	10.5	-	1000
Ct	56.2	13.2	2.7	9.8	2.5	2.5	3.5	TR	9.5	0.1	1000
Cs	57.6	10.3	3.5	8.8	2.2	2.4	3.3	TR	11.7	0.2	1000
Cv	57.5	10.2	3.9	6.8	2.3	2.7	6.6	0.1	10.0	-	2400
Xc	56.6	11.1	4.4	8.1	2.6	2.2	4.6	TR	10.4	0.1	
Tb	58.3	9.7	4.6	7.5	2.9	1.9	4.5	0.5	10.1	-	1000
Tt	56.6	10.5	4.4	10.2	2.6	2.5	3.6	0.2	9.3	0.1	1000
Ts	59.1	11.4	2.9	8.2	2.6	2.9	2.7	0.3	9.9	-	1000
Tv	58.7	11.1	2.6	8.9	2.9	2.5	4.0	0.8	8.6	TR	2400
Xt	58.2	10.7	3.6	8.7	2.8	2.5	3.7	0.5	9.5	TR	
GM	56.3	10.9	4.2	8.7	2.8	2.1	4.3	0.3	10.5	TR	
SD	1.95	1.19	1.25	1.10	0.45	0.63	1.10	-	1.21	-	

Abbreviations

RS = Rock sample

Xa = Average on sample A

Xb = Average on sample B

Xc = Average on sample C

Xt = Average on sample T

GM = Mean of A,B,C and T

SD = Standard deviation

PLG = Plagioclase

AUG = Augite

ACT = Actinolite

BIO = Biotite

APT = Apatite

QTZ = Quartz

PRH = Prehnite

KF = K-feldspar

OPQ = Opaque minerals

SPH = Sphene

TR = Trace amounts

CONT = Total point count

Fig. 3 - Photomicrograph of the 'lath-shaped' texture in the diabase. Crossed nicols. Horizontal dimension = 1.46 mm

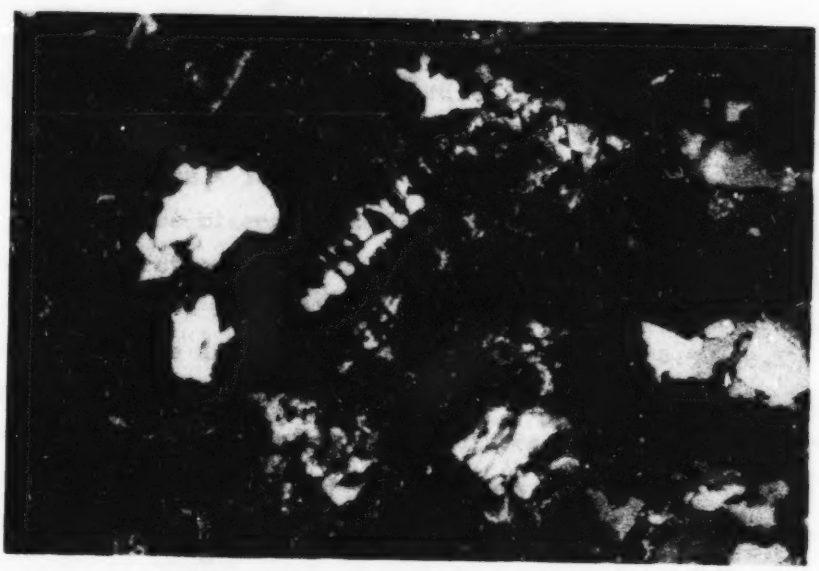

Fig. 4 - Photomicrographof the augite from the diabase showing marginal alteration to green actinolite, light-brown biotite with secondary magnetite on the rims. Crossed nicols. Horizontal dimension = 1.46 mm

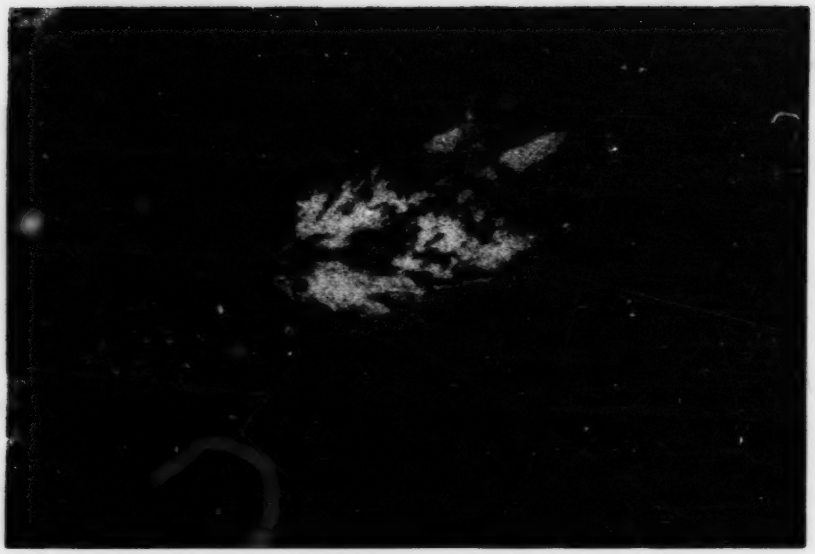

Fig. 5 - Photomicrograph of the 'bow-tie' texture of prehnite in diabase. Crossed nicols. Horizontal dimension = 1.46 mm

DENSITIES FROM MODAL VOLUME PERCENTAGE

The rock density is determined by taking the associated minerals densities of the studied rock multiplied by the modal analysis coefficients of the mineral constituents (Kamineni and Dence, 1976). The relation can be expressed in the following way:

$$\text{Rock density} = 0.01 \sum_{n=1}^{n} M_1 d_1 + M_2 d_2 + M_3 d_3 + \ldots + M_n d_n$$

where M is the modal volume percentage of a mineral and d is the average density of the mineral.

The average mineral densities that were used for the evaluation of density of amphibolite and diabase are taken from Deer et al. (1961) (Table 3).

The rock densities evaluated by this method for amphibolite and diabase are 3.03 and 3.05 (gm/cc) respectively.

CONCLUSIONS AND REMARKS

The amphibolite from Creighton Mine is a fine to very fine grained rock sample and has been subject to at least, three almost equal magnitudes of regional metamorphism. This is not a typical amphibolite in terms of the texture. However, from mineralogical assemblages point of view, slightly high in mica content and rather low in feldspars content, this rock sample could be classified as biotite amphibolite. The average grain-size of hornblende, plagioclase and biotite are in the ranges of 0.3 - 0.6; 0.5 - 0.6 and 0.3 - 0.7 mm respectively. Only limits of intragranular fractures are observed. The apertures of the two obvious major fractures which have been filled and recrystallized with quartz and quartz/carbonate are 0.9 and 0.09 mm in width.

The diabase is a very fine-grained aphanitic unmetamorphosed rock. The high contents of opaque minerals such as magnetite, pyrite and ilmenite are believed to be the duteric alteration products after augite and actinolite. The presence of prehnite is rather rare in diabase and it could be a secondary product after augite or actinolite. The high magnetic bulk suscep-

Table 3 - Average selected mineral density

No.	Minerals	Density (gm/cc)
1	Quartz	2.65
2	Plagioclase	2.65
3	Augite	3.24
4	Actinolite	3.23
5	Biotite	3.00
6	Apatite	3.23
7	Prehnite	2.93
8	K-feldspar	2.60
9	Opague minerals*	5.00
10	Hornblende	3.23
11	Sphene	3.50
12	Muscovite	2.83
13	Chlorite	2.95
14	Carbonate (calcite)	2.72

*Average density of magnetite, ilmenite and pyrite.

tibility, aphanitic texture and high contents of opaque minerals characterize the typical diabase. The magnetic anisotropy investigation results indicate that there is only one weak magnetic plane which is aligned. As a result, from a geological point of view, this diabase is a uniform, massive and truely randomly oriented mineral.

ACKNOWLEDGEMENTS

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REFERENCES

1. Deer, W.A., Howie, R.A. and Zussman, J. "An introduction to the rock-forming minerals"; 1965.

2. Kamineni, D.C. and Dence M.R. "Preliminary petrographic and petrofabric study of samples from drillhole WN2"; Technical Data 303415-M01/79; 1979.